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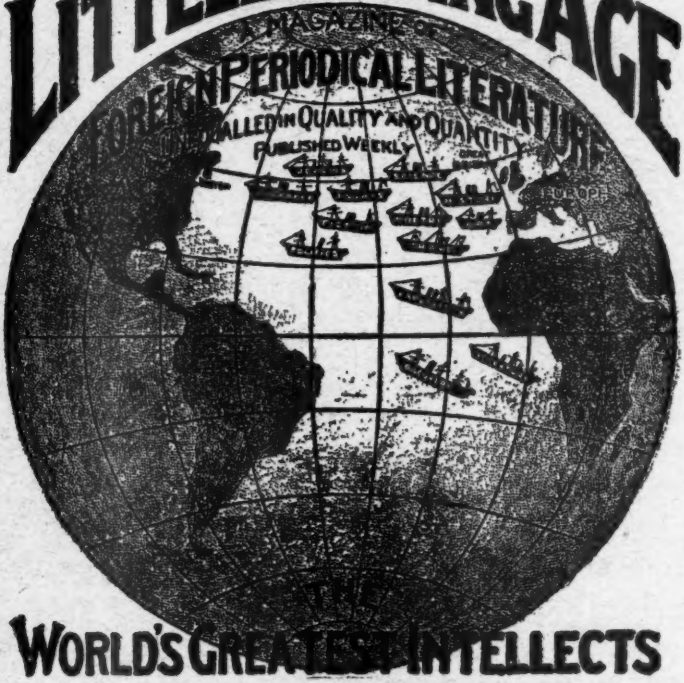

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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. XII. BOSTON, MASS., MARCH, 1896. No. 11.

THE DIURNAL OSCILLATION OF ATMOSPHERIC PRESSURE AT THE PERUVIAN STATIONS OF HARVARD COLLEGE OBSERVATORY.*

PROF. S. I. BAILEY.

EIGHT meteorological stations are now maintained in Peru by the Harvard College Observatory. They are situated as follows: —

Mollendo. The meteorological shelter is situated in the town, near the Pacific, at an elevation of about eighty-five feet above sea level.

La Joya. The station is in approximately the centre of a rainless, barren region, known as the Desert or Pampa of Islay. The elevation is 4,140 feet.

Arequipa Observatory. Elevation 8,050 feet.

Summit of El Misti. Elevation 19,200 feet.

Flank of El Misti. (M. B. Station.) Elevation 15,700 feet.

Alto de los Huesos. A lofty desert pampa, east of El Misti; elevation 13,400 feet.

Cuzco. Valley or plateau, between Eastern and Western Andes; elevation 11,100 feet.

Santa Ana. East of the Andes in the Urubamba Valley at an elevation of 3,400 feet.

These stations are provided with Richard Frères' thermographs and barographs, with mercurial thermometers, rain gauges, wind vanes, and sunshine recorders. Records for comparison are, in general, made thrice daily.

The Misti stations were established by the writer in September, 1893, and those at Cuzco and Santa Ana in July, 1894.

To visit Cuzco from Arequipa, it is necessary to travel by rail two days and on mule-back three days. To reach Santa

* Communicated by Edward C. Pickering, Director.

Ana requires four days of hard mule-back riding beyond Cuzco, in a region abounding in many hardships. Santa Ana is near the border of civilization, and the observations are made by a wealthy "Haciendado," Señor Duque.

These stations extend in a direction approximately north and south across the Andes from the Pacific to the headwaters of the Amazon. They lie between latitude 12° south and 18° south, and longitude 4h. 40m. and 5h. west from Greenwich.

Diagram 1 shows their relative distances and heights, and the approximate mean atmospheric pressures. The main crest or crests of the Western Cordillera lie between Arequipa and Cuzco. The Eastern Andes, a magnificent range, are between Cuzco and Santa Ana.

No mercurial barometer has been regularly in use at any station except Arequipa. Comparisons were, however, made with a mercurial barometer whenever possible.

An unusual number of difficulties rendered the records at the Misti Summit station less continuous than was expected. In September, 1894, the shelters were found broken open and several instruments stolen. The station was promptly restored, but the civil war, which raged throughout a large part of the year, made travel at times inexpedient. From these causes chiefly, together with the heavy snows near the summit during the cloudy season, no records were obtained there during the months of September and October, 1894, and February and March, 1895.

Mr. S. P. Fergusson, of the Blue Hill observatory, has recently constructed a meteorograph for this summit station, which is capable of running nearly four months without rewinding. This instrument has already been placed in position, and is now running, so that continuous records throughout the year may reasonably be expected. At Arequipa regular readings of the mercurial barometer are made thrice daily. The following table gives the results for the year, April, 1894, to March, 1895, inclusive. The first column gives the month, and the three following the mean pressure at 8 A. M., 2 P. M., and 8 P. M., expressed in thousandths of an inch, omitting the constant quantity, 22 inches. The fifth column gives the means; the succeeding columns give the maximum and mimimum pressures and the range for the same hours. The values are reduced to 32°F.

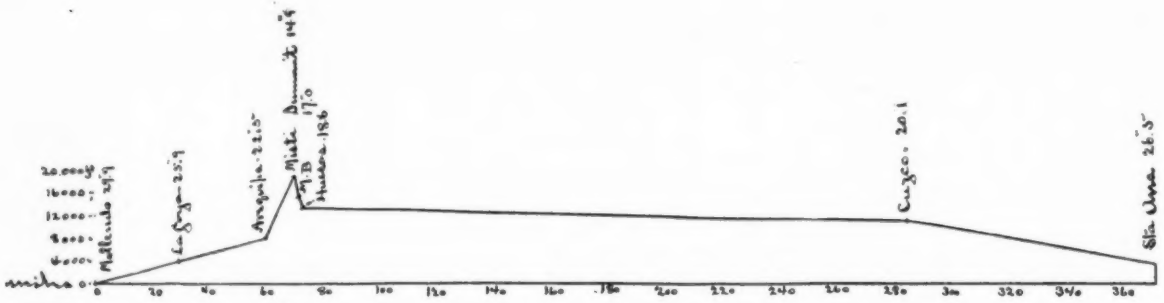


Diagram I. Relative Distances and Heights of the Harvard Peruvian Meteorological Stations

Diagram II Hour of 9 A.M. maximum pressure

TABLE I.—MEANS OF BAROMETER READINGS, AREQUIPA.

	8:00 A. M.	2:00 P. M.	8:00 P. M.	Mean.	8:00 A. M.			2:00 P. M.			8:00 P. M.		
					Max.	Min.	Range.	Max.	Min.	Range.	Max.	Min.	Range.
1894.													
April,	521	484	529	511	567	473	94	543	439	104	585	489	96
May,	529	488	530	516	569	479	90	533	453	80	570	477	93
June,	547	501	545	531	626	487	139	554	457	97	591	493	98
July,	548	513	545	535	603	514	89	586	483	103	579	499	80
Aug.,	529	484	536	516	571	486	85	524	445	79	575	493	82
Sept.,	530	500	544	525	584	471	113	555	447	108	595	477	118
Oct.,	523	484	534	514	566	483	83	572	436	136	597	493	104
Nov.,	521	481	539	514	569	447	122	528	431	97	581	491	90
Dec.,	513	481	530	508	588	437	151	561	411	150	613	467	146
1895.													
Jan.,	497	464	513	491	544	445	99	503	404	99	569	451	118
Feb.,	525	484	529	513	607	485	122	565	448	117	602	487	115
March,	519	483	529	510	607	454	153	548	421	127	585	487	98

The highest recorded pressure for the year was 22.626 inches
" lowest " " " " " " " 22.404 "

The former was at 8 A. M., June 25, 1894, and the latter at 2 P. M., Jan. 28, 1895.

The mean pressure for the year, determined from these readings, was 22.515 inches.

The maximum range during the year, 0.222 inches.
" " " " one month 0.153 "
" minimum " " " " 0.079 "

The mean pressure in June was 0.023 inch greater than in December; in July 0.044 inch greater than in January. The mean pressure of the six months, April to September, was 0.007 inch greater, and of the six months, October to March, 0.007 inch less than the mean pressure for the year.

At Arequipa a comparison has been made between the results obtained from the mercurial barometer and the Richard barograph. This is shown in tables II. and III. Table II. gives the differences between the monthly means of the barometer and barograph at 8 A. M., 2 P. M., and 8 P. M.

A uniform correction of +0.393 was applied to the barograph readings. By applying a monthly or weekly correction more

accurate results would doubtless be obtained; but it was desired to learn what errors might be expected, where such frequent checks were impossible.

TABLE II. DIFFERENCES BETWEEN MONTHLY BAROMETRIC AND BAROGRAPHIC MEANS.

	1894.									1895.			
	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean.
8:00 A. M.	+.003	−.020	+.005	+.003	+.010	−.016	−.011	−.002	−.009	+.009	+.034	+.021	+.009
2:00 P. M.	−.007	−.034	−.011	−.007	−.010	−.018	−.031	−.008	−.021	−.003	−.015	−.007	−.002
8:00 P. M.	+.005	−.018	+.007	−.001	+.014	−.001	.000	+.011	−.006	+.022	+.031	+.028	+.008

Assuming the barometric means to be correct, after applying a constant correction for reduction to the same scale, the barographic means are thus liable to an error as great as 0.034 inch, and the mean error of the year, irrespective of sign, is 0.013 inch.

The differences between the monthly ranges of the two instruments are shown in Table III.

TABLE III. DIFFERENCES BETWEEN MONTHLY BAROMETRIC AND BAROGRAPHIC RANGES.

	1894.									1895.			
	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean.
8:00 A. M.	+.07	−.02	−.02	.00	.00	−.01	.00	−.02	+.01	.00	.00	−.03	.00
2:00 P. M.	+.03	−.01	−.02	.00	.00	−.02	−.06	+.01	−.01	−.01	−.01	−.02	−.01
8:00 P. M.	+.06	−.03	−.01	+.01	+.01	−.03	−.01	.00	−.01	+.01	+.01	.00	.00

At all the stations the diurnal oscillations are well marked and very uniform from day to day. There are striking differences, however, between the records at the different localities, especially in the hour of the morning maximum, and the intensity of the afternoon minimum and maximum.

All these facts will best appear from the curves representing the diurnal oscillations.

Diagram III. gives the curves of mean diurnal oscillations for the year, April, 1894,–March, 1895, with the exception that the months of September and October, 1894, and February and March, 1895, are wanting for the Misti Summit Station, and April–June, 1894, for Cuzco and Santa Ana.

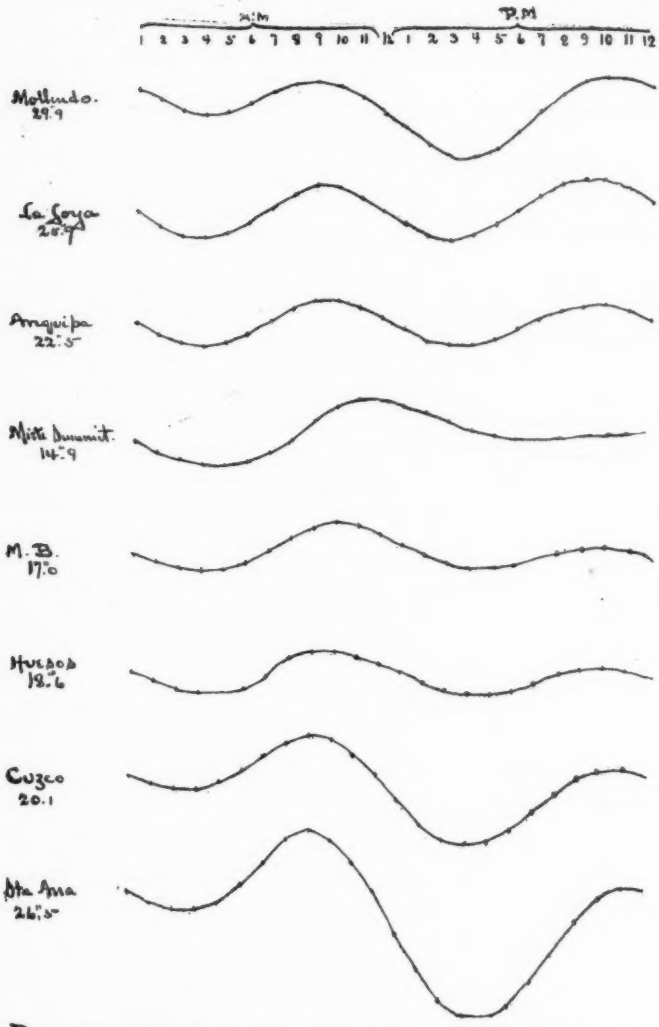


Diagram III. Curves of Mean Diurnal Oscillation of the atmosphere Pressure for year April 94 - March 95-

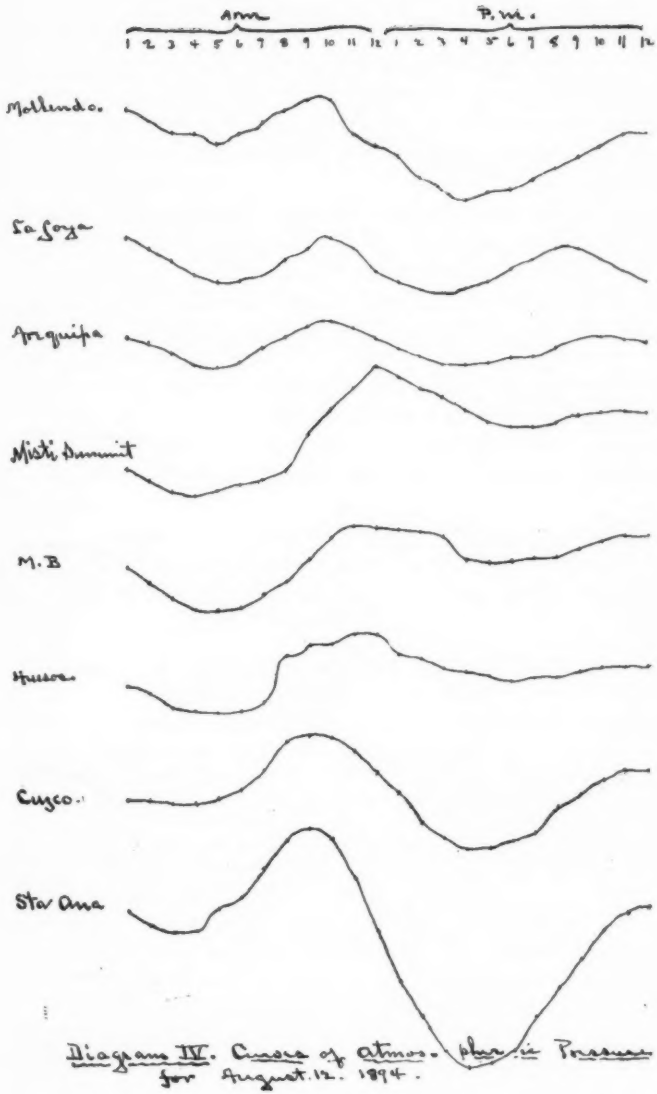


Diagram IV. Curves of atmos. pressure for August 12. 1894.

Diagram IV. gives the corresponding values for a single day, Aug. 12, 1894. This day was selected at random — almost any other day would have shown the diurnal variations equally well. In both diagrams the scale is magnified ten times, one vertical inch representing one tenth of an inch of the barometer in the original drawing. The printed diagrams are on two thirds of the original scale.

From these curves it appears that the retardation of the morning maximum is, at least in part, a function of the altitude. *Diagram II.* is an attempt to illustrate this graphically. The hour of the morning maximum is perhaps also affected by the season, but this effect seems small and has not yet been sufficiently investigated.

On April 23 and 24, 1894, hourly readings of the mercurial barometer were taken for twenty-four consecutive hours on the summit of the Misti, by Mr. Waterbury and the writer. Hourly readings were also made at the same time at the observatory in Arequipa.

Table IV. gives the results reduced to the freezing point. The distance between the two stations in an air line is about ten miles and the difference in elevation about eleven thousand feet.

TABLE IV. — SYNCHRONOUS BAROMETRIC READINGS.

AREQUIPA AND SUMMIT OF EL MISTI.

	April 23, 1894, A. M.			April 23, P. M.								
	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00
Arequipa.	546	539	536	531	521	513	515	533	546	563	565	583
Misti.	871	876	855	834	822	827	829	834	847	842	856	858
	April 23, P. M.			April 24, A. M.								
Arequipa.	581	579	567	554	541	536	524	523	530	556	—	529
Misti.	856	856	857	845	839	832	836	832	840	852	859	874

For Arequipa the constant value 22 inches is omitted from the table, and for the summit 14 inches.

Both observers on the summit suffered, during the night especially, from cold and mountain sickness.

It is hoped that the accuracy of the observations did not suffer on that account.

AREQUIPA, Dec. 2, 1895.

CYCLONES AND ANTICYCLONES.

A SPECIAL PLEA FOR ATMOSPHERIC EXPLORATION.

PROF. H. A. HAZEN.

IT is a noteworthy fact that meteorologists, though they have had to deal with the most complex phenomena in nature, have been content for the most part to theorize. It is safe to say that no physical science of any pretensions has neglected to put her questions to nature as has meteorology. As a consequence there has been a great revulsion in modern times, and scientists are beginning to feel that we really know less to-day regarding atmospheric movements than we thought we knew ten years ago. All along the line there has arisen a demand for facts, and already researches of a notable character, in hitherto well-nigh unexplored fields, have been undertaken. It is my purpose to briefly review the history of studies and theories of cyclones and anticyclones and to set forth the field and its work.

Meteorology has established the principal facts to be gleaned at the earth's surface regarding the pressure, temperature, dew-point (humidity), rainfall, wind velocity and direction, and cloud movement in cyclones and anticyclones. This, however, has been purely superficial and we find almost no knowledge of what produces these effects. Instead, theories and speculations as to the cause of the most profound and complex movements of the gaseous envelope above us have filled the air. I do not decry any results which have been obtained through synoptic charts; they have undoubtedly advanced the science wonderfully and have enabled us to disprove a great many theories. These charts, however, reveal almost nothing of the true mechanism of a cyclone or anticyclone. We do not know to-day the first step in rain formation; some claim that the temperature in a rain cloud must be lower than that in the surrounding air; others claim that unless the temperature is higher there could be no rain at all.

ESPY'S THEORIES.

For scores of years men had been content to note wind, temperature, rainfall, etc., at single separate stations on the earth. Espy of our own country was the first to correlate these phenomena for a very large number of stations, and this, too,

nearly sixty years ago. He found that in large storms the winds have a general tendency inward and this led to the theory that there was an uprush of air in the centre of the storm. This air, moist and warm, would condense its moisture from the cold of expansion, and the latent heat liberated would tend to still farther increase the partial vacuum and to a more rapid upward flow of the air. The storm then would have a power of increasing itself the moment the initial impulse was started, though that may have been of the slightest. A little more heat from the sun at one point at the earth or a slight non-homogeneity in the air causing an unstable equilibrium would give rise to most intense storms. The action was described as that in a steam engine where the expansion and condensation of the steam produces such powerful effects. One scientist in his enthusiasm actually computed that in the case of a West India cyclone of great proportions the rainfall represented a condensation which would have equalled 473,000,000 horse-power, or more than all the steam engines, windmills, waterfalls, animal and human labor of the globe in the same time. Espy's views were strongly combated at the time but obtained a foothold which has been maintained even down to the present time.

PROF. FERREL'S VIEWS.

The most notable champion of Espy's views was another American, Prof. Wm. Ferrel, who began his writings in 1856. To avoid all possibility of misapprehension I will give Prof. Ferrel's own words in describing cyclones: "When, on account of greater heat, or a greater amount of aqueous vapor, the atmosphere at any place becomes more rare than the surrounding portion, it ascends, and the surrounding heavier atmosphere flows below, to supply its place, while a counter-current is consequently produced above. As the lower strata of atmosphere generally contain a certain quantity of aqueous vapor, which is condensed after arising to a certain height, and forms cloud and rain, the caloric given out in the condensation, in accordance with Espy's theory, produces a still greater rarefaction and doubtless adds very much to the disturbance of equilibrium and to the motive power of storms." Some years later we find: —

"The complete temperature conditions of a cyclone, therefore, rarely extend down to the earth's surface, but the interchanging

and gyratory motions, commencing first up in the cloud regions, are soon propagated downwards to the earth's surface by the action through friction of the upper strata upon the lower ones." Here we see a distinct advance in thought, for now the initial disturbance is aloft and not at the earth.

These quotations might be added to, very greatly, but enough has been given to show the general tendency of thought regarding such theories. We have presented more or less vertical columns of air of less density than the surroundings, and these columns carried along the earth's surface form our cyclones.

OBJECTIONS TO THESE THEORIES.

First. Rain does not occur at the centre of the cyclone at which point the winds converge and where we may well suppose there must be the greatest ascensional movement. Rains in the United States east of the Mississippi River actually occur 300 or 400 miles east of the cyclone centre, and just where there is no upward tendency indicated by either the isobars or the winds. It has been suggested that possibly rain does form in the centre, but is carried by the upper current to a point beyond the centre; a little reflection, however, will show that if the upper portion of the cyclone, which itself is a mere disk some 5,000 or 6,000 feet thick, is borne along by the current, the rain drop cannot be carried beyond the cyclone centre and dropped at a distance of 400 miles by the same current.

Second. The velocity of the wind current, as one rises in the air, continually enhances and at 6,000 feet it is about double the velocity at the earth. Under these conditions it is easy to see that no column of air could maintain its continuity, even if formed for a moment. The upper portion would be borne along at a velocity greatly in excess of the lower, and the whole column would be effectually disintegrated in a few minutes.

Third. It would be impossible in a frictionless medium to maintain any partial vacuum for a few minutes even after it was formed at any point in a vertical column, for the air would rush in and fill such a vacuum with the velocity of sound very nearly. This would also seem to effectually dispose of the steam engine theory. We have in the atmosphere no cylinder or piston, or in fact any of the apparatus needed in actuating a steam engine except the boiler.

Fourth. There is no ascending current in a cyclone. At least no such current has ever been noted satisfactorily. The appearances seeming to show such current can be explained in other ways. To place in the air a cylinder of such consistency that air can only enter at the bottom as into a chimney and nowhere else, and at the same time have the air a frictionless medium, seems altogether too great a task for the imagination even.

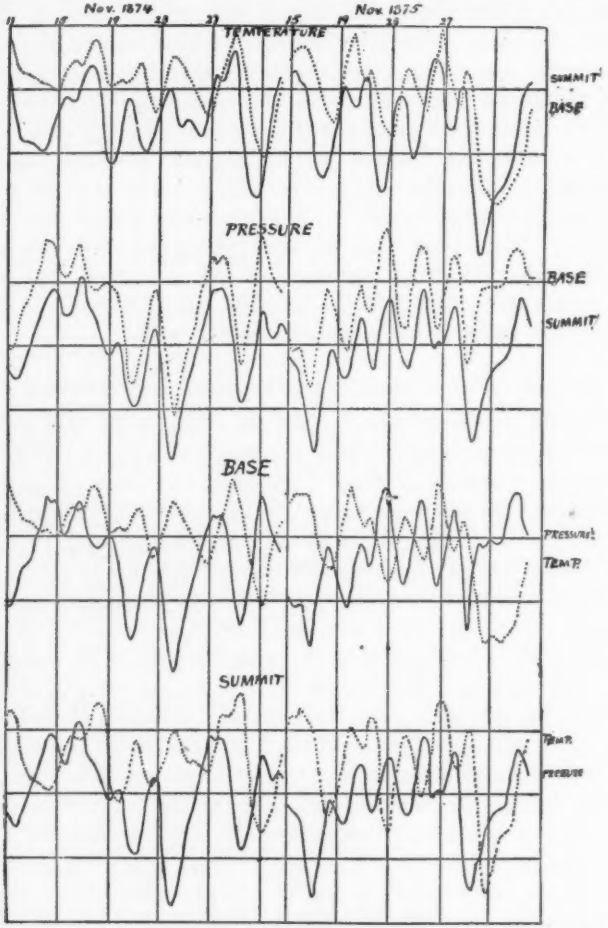
Fifth. The effort in later years to transfer the energy of the cyclone to a convenient height, and then to bring down its gyrations to the earth through a frictionless medium seems extremely strained. It has been computed that through friction alone such gyrations would be transmitted downward at the rate of about 300 feet in about 20 years. It is not necessary to amplify these objections though many more have been urged.

ACTUAL CONDITIONS OF TEMPERATURE AND PRESSURE.

It is of the greatest moment that we obtain some idea of the actual conditions in the cyclone, especially at some height above the earth. On the one hand, there could be no ascending current unless the temperature were higher than the surrounding air, and, on the other hand, if the temperature rises at all it would have a tendency to stop all precipitation. For determining these conditions we have, very fortunately, several mountain stations in the world, and the best of all these is in the United States at Mt. Washington, N. H., with Lunenburg Vt., a station very near its base. This mountain rises almost abruptly from a plain. Gorham, Me., eight miles distant, is but seven hundred feet above the sea. More than this a large share of the cyclones and anticyclones pass directly over the mountain. In studying variations of pressure we may take the observations as made, but with the temperature some attempt must be made to eliminate the diurnal range or else we must take only a single observation each day. The best way to eliminate the diurnal range is to take the mean of any number of successive observations at the same interval apart. For example, if observations are taken at 7 A. M., 3 and 11 P. M., each day, we could take the mean of 7, 3, and 11, then 3, 11, and 7, then 11, 7, and 3, and so on.

Chart 1 shows temperature fluctuations at Mt. Washington full black, and Lunenburg dotted black. There is a most remarkable accordance in these curves showing identical fluctu-

ations at both summit and base. As a general thing the range from the highest point to the lowest is greater at the summit



than at the base. This precludes the possibility, as thought by some, of the earth's surface receiving changes in temperature first and then conveying them through convection to the atmosphere above. We also see that the summit crests and hollows precede those at the base by eight to sixteen hours. This is an extremely significant fact, as the sequel will show.

Chart II. in like manner, shows changes in pressure at the summit (full black) and at the base (dotted black). Here again the oscillations are identical, both above and below, and are more nearly alike than in the case of temperature. In this case, however, the crests and hollows occur some eight hours *later* at the summit than at the base instead of earlier as in the case of temperature. This is also very significant.

Chart III. shows fluctuations in temperature and pressure at Lunenburg (base). Here we see the universal rule carried out that has been observed at every temperate region station of the world, that is, a fall in temperature coincident with a rise in pressure, and *vice versa.*

DR. HANN'S STUDIES.

We now come to one of the most startling investigations in meteorology whereby Dr. Hann has tried to show that the usual law at sea level is exactly reversed at Mt. Washington or at any height above 6,000 feet, and that here the temperature at the centre of a cyclone is lower than in the centre of an anticyclone. It will be seen at once that if this be true the whole modern theory and convection hypothesis of cyclones and anticyclones would fall to the ground. I doubt if there is in the annals of science a more remarkable case of an improper use of observations than this. There is a saying, "figures won't lie," but they can be sometimes distorted into giving just the opposite result from the truth, and this is a case in point. The singular thing is that meteorologists over the world have taken the authority of Dr. Hann and have readily given up the whole convection hypothesis on the *ipse dixit* of one man without attempting to check his work in any way. We have already seen in Charts I. and II. that the temperature and pressure oscillations are identical at the summit and base of Mt. Washihgton, and hence so far as these facts go the conditions above in cyclones are the same as below. How is it possible for Dr. Hann to have interpreted these records so erroneously? The story is an intensely interesting one.

Dr. Hann thought that he would compare together temperature and pressure fluctuations at the summit of a high mountain. He found that they were not opposite each other as at the base, but by pushing the temperature maximum and minimum points

twenty-four hours ahead he found that the fluctuations of temperature and pressure were identical, or had exactly the same phases. We have already seen, in the first set of curves above, that the temperature oscillations are about sixteen hours earlier at the summit than at the base. Now, Dr. Hann, by pushing them twenty-four hours still farther ahead has made them *forty hours out of place, and has actually compared the temperature oscillations, not with their own changes in pressure but with the changes in pressure of anticyclones and cyclones succeeding the proper cyclones and anticyclones.* In other words, he has compared the rise in temperature that belongs to a cyclone with the rise in pressure that belongs to the anticyclone which precedes the proper cyclone. This is brought out very clearly in the fourth set of curves. I have already stated that at the summit the temperature is sixteen hours ahead of the base, so it is necessary to put back the temperature sixteen hours. This has been done in the fourth set of curves and now we see that the oscillations of temperature are exactly opposite those of pressure at the summit just as they should be. This fact is also brought out very clearly on comparing the third and fourth sets of curves. I have thus dwelt at length upon these researches and conclusions of Dr. Hann for the reason that they have been called "epoch making" and have resulted in the acceptance of a new theory put forth by Dr. Hann.

THE NEW HANN THEORY.

Our cyclones are generated in the poleward moving currents and are simply enormous eddies in this current at great heights above the earth which communicate their gyrations to the earth. It is impossible to tell which is worse, — the original investigation obliterating the convection hypothesis or this new theory.

First. There are no obstructions or cross currents or any other possible ways in which such a whirl could be formed at 15,000 or 20,000 feet above the earth.

Second. There are no poleward directed currents at that height.

Third. Even if such an eddy were formed in the upper current it would require hundreds of years for it to communicate its gyrations to the earth through a frictionless medium.

Fourth. There are no whirls or spirally-moving winds above 4,000 feet.

Fifth. Absolutely no precipitation could be formed in a whirl gradually propagating its motion downward.

Sixth. If such a whirl were started it would entirely lose its continuity in passing down through strata of the atmosphere having greatly different velocities.

One of the singular results of these unique manifestoes from Dr. Hann has been the acceptance of the view that tropical cyclones are still formed according to the old convection hypothesis but those farther north cannot come under that theory. Here are two conditions which are absolutely identical as regards precipitation, clouds, isobars, etc., and yet the exigencies of the case seem to demand a different mode of generation, and so this is launched upon meteorology. I do not see how any one at all familiar with the matter in hand or who accepts the perfectly impartial showing that I have here given could not but be lead to repudiate without a moment's hesitation these wild and half formed speculations.

MOISTURE OF THE ATMOSPHERE.

If we measure carefully the moisture contents (grains per cu. ft.) of the air, hour by hour, we will find that this element is by far the most constant in meteorology. The temperature may rise 40° during the day, and fall again at night, but the moisture in the air will not change. No direct changes in pressure will affect it, no clouds, no wind. I have known the wind to blow more than a day directly from the Atlantic upon the coast without changing the moisture contents. Some hours before a cyclone arrives, however, and before it begins to rain, the moisture in the air changes very rapidly. In an unused bathroom, which I could close and almost hermetically seal, I have covered the floor with plates full of water and have filled the bath tub, and yet the air has remained for weeks without becoming saturated. The remarkable thing in this experiment was that the moisture in the air in the bathroom had precisely the same changes as that outside. The only way in which this experiment can be positively verified, and the absolute truth established, is to measure the moisture in a chamber that has been hermetically sealed. If this point could be established, it would show beyond a per-

adventure that the moisture in the air is not dependent for its changes upon heat, pressure, wind, or any other element commonly recognized in meteorology. I ought to say that, in the bathroom experiment above, the sun shone directly upon the part of the house where it was, and the temperature frequently changed 20° in a single day.

One of the most important problems in this connection is as to the means by which moisture reaches the air; there is undoubtedly constant evaporation from moist earth, water-courses, swamps, lakes, and the ocean, but this moisture is diffused at once through the atmosphere and does not affect our measures. At the time of a cyclone, however, the sun is hidden by clouds and the evaporation becomes almost *nil*, except by wind, and yet we have an enormous increase in the moisture. On the other hand in the anticyclone which follows, the sun is at his full intensity, but the moisture almost disappears from the air. I have known cases where in a perfectly still air the moisture has dropped more than half in an hour. A settlement of this single question would be of inestimable advantage in meteorology. Balloons have shown most remarkable horizontal layers in the moisture of the air.

At Philadelphia, Pa., in 1887, there was a drop of 45% in the relative humidity in two layers 1,000 feet apart vertically. At Washington, D. C., in 1891, there was a difference of 30% in two layers 400 feet apart. The most remarkable change, however, was observed at Stockholm, Sweden, a year ago where two layers of air, 1,800 feet apart, differed by 96% in relative humidity, or a change from saturation to almost perfect dryness, and a dryness *never* noted at the earth except in arid regions. All these observations were made with the most perfect apparatus, giving the relative humidity within 0.2%, or at the most 0.5% of the exact truth.

Such records as these make us long for more observations, and such as will enable us to note changes once or twice each day in a vertical height of 20,000 feet. How do these layers change as a cyclone comes up? There are indications that there are almost permanent layers of moisture at rather definite heights. Vettin found in Germany that there were layers of clouds at definite heights, and the same kind of clouds were found in a thin stratum at the same height day after day. Are

these streaks of moisture conveyers of electricity as Prof. Loomis very guardedly stated years ago? What is their motion as a cyclone comes up? Do they thicken and finally coalesce? How does the rain form in these layers? What is the temperature? What is the electrical condition?

A partial answer to the last question may be found by the behavior of clouds on Mt. Washington, N. H., 6,300 feet above the sea. It is known that in the warmer months there is almost a perpetual cloud cap on the summit. The telephone is sputtering and crackling at the summit all the time just as it does at the earth only when a severe thunderstorm is in progress. There are a great many evidences that there is a constant stream of electricity passing off from the summit precisely as from a point on an electrical machine. Some have thought the perpetual cloud was due to the fact that the summit was cooler than the air and condensed the moisture, but careful observations of the rocks at the summit showed that they were always *warmer* than the air. This cloud cap is ordinarily of very limited extent, and it is a very easy matter to come out from it by walking down the mountain a short distance from the summit. A very careful study of this cloud cap shows that it is intimately associated with, if not directly caused by, the passage of electricity from the summit.

WHAT IS A CYCLONE?

I think the evidence is conclusive that it cannot be anything like a cylinder of air borne along by an air current. It would seem that the following points are pretty well established: —

First. The conditions of a cyclone, such as temperature, pressure, and electricity, extend far beyond the tops of our highest mountains. The fluctuations of pressure and temperature on Pikes Peak, Colo. (14,134 feet), are nearly the same in point of time and in extent as those below. Temperature fluctuations on Mt. Washington are *greater* than at the earth's surface. If this single point could be established beyond doubt it would be of the utmost importance.

Second. The motion of a cyclone is entirely independent of air currents at any height in our atmosphere. This would seem self-evident, for the motion of different strata is greatly increased as we recede from the earth, and such motion would quickly

disintegrate any condition that was not independent of such currents. It may seem impossible at first sight to conceive of a condition in the atmosphere that is not borne along by the wind. Suppose there were an enormous white-hot ball carried along in the air and there were thermometers at the earth delicate enough to indicate the slightest temperature changes. In such case the thermometers would seem to show an advancing hot wave in the air which, however, would not be due to any heated air wave borne along by the current, but would be independent of the current.

Third. The moisture in a cyclone is not supplied directly by evaporation nor is it carried by air currents alone in any direction.

Fourth. Our cyclones and anticyclones are largely dependent upon conditions beyond our atmosphere for their energy.

Fifth. They are in the nature of fields of minus and plus electricity. Our electrometers invariably show negative atmospheric electricity during the fall of rain, and positive electricity in clear weather. The tendency is for particles to fly from the positive to the negative pole, for example, in an arc light. Why may not moisture particles in the same manner be driven to the negative field? I have consulted prominent electricians, and they assure me that this is a most hopeful line of investigation and study. If such a possibility as this be admitted we shall have no difficulty in accounting for the enormous increase of moisture in the air as our cyclones approach. There are frequently used common expressions, such as, "This is a pet day," "This is a weather breeder." These expressions are used in regard to a perfectly cloudless sky, and such a sky is very often a forerunner of a severe storm. Why may not the moisture in the atmosphere in such a sky be driven out or repelled to the westward by some source of energy entirely distinct from heat or from the wind? The latter we know cannot be the cause for the wind is from the west to the east at heights of 5,000 feet and over.

I have tried to bring this question of an electrical transmission of particles, or, better, an electrical repulsion and attraction of vapor in the air, to a practical test in the laboratory. Electricians say that the best method of obtaining a negative or a positive field in the air is with a Holtz machine. Most careful

tests of the change in moisture in the air of a room with a negative field at a Holtz machine have shown an increase of moisture at the machine. Prof. Dolbear assures me that he has found indications in the same direction.

ELECTRICITY IN STORMS.

Meteorology has always taught that the electricity of thunderstorms is a result of friction of the air upon the earth, and that it has nothing to do with the generation of the storm. Moreover there are no visible manifestations in our severest winter storms. Electrometer tests prove beyond question the presence of electricity in all storms. Observations have also been made on the effect of an approaching storm on the nerves of persons who have lost a limb. The most noted of these observations are those of Capt. Catlin, of Washington, D. C., who has recorded his sensations or "hours of pain" in his leg, which he lost in the Rebellion. He has correlated these hours of pain with temperature, pressure, rainfall, wind, and all the common meteorological elements, and has found no invariable connection, but he has found a marked correspondence between his pains and the presence of atmospheric electricity. Observations with kites at heights of even 500 and 1,000 feet have shown an enormous increase in the electric potential at these moderate heights. There can be no doubt that the upper air contains a tremendous store of electricity which is perpetually renewed by the action of the sun. Some believe that sunlight has the power of electrifying the air. All attempts to determine the source of this electricity in the atmosphere have given negative results. We know that it is not due to evaporation, nor to the growth of plants, nor to changes in temperature. The electric storms on the sun transmitting their outbursts with the velocity of light to the earth and there swinging our magnetic needles show where our electricity may originate. Meteorology has attempted to associate all our storms with heat phenomena, pure and simple, and yet the heat of the sun is warded off from the earth almost entirely at just the time when it is most needed in producing a storm. Why may not there be a transformation of some of the sun's heat or light into electricity on reaching the atmosphere? Or possibly the direct electric emanation from the sun may produce effects upon our atmosphere which culminate in storms.

PROF. MENDENHALL'S RESEARCHES.

A few years ago a series of electrometers were placed at several points in this country and changes in electric potential were most carefully observed for many months. On examining these records with existing storms at the time, Prof. Mendenhall announced a negative result, that is, the observations did not show a direct connection between electric changes and the approach or disappearance of storms. These observations were made with the most accurate instruments and cannot be disputed. On the other hand Father Secchi was confident that he could foretell the approach of a storm by his magnetic record twenty-four hours before any meteorological instrument was affected. Then again there is not the least doubt that there is an electric condition in the atmosphere that makes its presence felt to our nerves before the approach of a storm. I have most carefully investigated this question and have found men who have lost a limb who can foretell a storm about a day before it arrives and without knowing of any meteorological change or seeing a weather map. Is not the uneasy sensation experienced by many animals before a storm due to this peculiar condition of the atmosphere? I have a great admiration for Prof. Mendenhall's work and would not decry it, but it seems to me that there may be an explanation of this negative result found by him. Capt. Catlin has satisfied himself that there are several kinds of manifestations of electricity in the atmosphere; some of these affect his nerves while others do not. Can we say that our electrometers are suited to measure all forms or manifestations of atmospheric electricity? Again all the water droppers used for collecting electricity were less than seventy feet above the ground and were mostly on buildings. Why may not the electrical potential of the air at that height or of the building have been the same as that of the earth? If so, this would account for the negative result. The evidence of electric action in our storms is so overwhelming that every effort should be made to continue this work of Prof. Mendenhall's.

PLAN FOR EXPLORING THE ATMOSPHERE.

I have tried to show that meteorology has yet to lay her first foundation stone for an exact science. That the great need

to-day is of facts from the region where all our storms take their origin, that all efforts to associate the cause of storms with temperature conditions have signally failed. That the most promising line of research is in connection with the observation of atmospheric electricity. That this electricity must be measured at far greater heights above the earth than heretofore attempted. It is very evident, then, that we must enter the ocean of air above us and note all its changes, especially in our storms.

MOUNTAIN OBSERVATIONS.

There are many who have hoped that all needed records could be obtained from the summits of our lofty mountains where it would be possible to maintain continuous records throughout the year at a very slight expense as compared with any other method of exploring the air. We have records for seventeen years from the summit of Mt. Washington, and I have studied these with great care. There is no doubt that a full series of records at the base in conjunction with similar observations at the summit would be of inestimable value ; and it is greatly to be hoped that such observations may be begun and carried out under purely scientific auspices ere long (the station at Mt. Washington was practically abandoned by the Signal Service in 1887). Especially is it true that electric observations would be of the utmost importance at two such stations (none at all have been made thus far). However, with all the advantages accruing from such continuous records at a mountain station we can never get rid of the fact that the mountain is simply a continuation of the earth and that the atmospheric-electric conditions, especially at the summit, are vastly different from those in the free air a mile or two away. The point is that the electric condition of the earth must modify and essentially change the supposed free air condition at the summit of the mountain. I do not now see any possible way of overcoming this influence. Clouds at the summit are undoubtedly caused by this terrestrial condition and they extend to at least two thousand feet above the summit and to two or three miles on all sides. It may be possible to anchor a balloon to the summit of Mt. Washington by a cable two or three miles long, but under the most favorable circumstances I do not think it would be possible to obtain anything like free air observations near such a point of the earth.

While the temperature and air pressure would be approximately accurate, the electricity, moisture, wind direction and velocity, rainfall, clouds, in fact, every other element could not be observed at all correctly. The rainfall at Mt. Washington is double that at the base and this is due to the peculiar electric condition. We are forced then to enter the free air directly and at a distance from all mountains.

BALLOONS.

There is no motion to which a balloon can lend itself so readily as to one of passing rapidly into the air and just as rapidly moving back to the earth. During this passage it is possible to determine with the extremest accuracy the temperature, moisture, clouds, rainfall, wind direction and velocity, and with approximate accuracy the electric condition. I do not now see why the latter may not also be obtained accurately, but electricians are disposed to think that there may be some difficulties in the way of obtaining a sufficiently accurate standard of measurement when free from the earth. Aeronauts abroad have succeeded in obtaining very good observations of electricity. The balloon, for the greatest serviceability should be made of gold-beater's skin, and should have a capacity of about thirty-five thousand cubic feet. It is claimed abroad that such a balloon would retain its hydrogen with a loss of less than one per cent in twenty-four hours. As hydrogen can be had in large quantity for less than five dollars a thousand cubic feet (some say thirty cents per thousand), it will be seen that, after the construction of the balloon, the total expense would be merely nominal.

SAFETY OF SUCH RESEARCH.

However desirable a scientific exploration of the atmosphere might be it could not be regarded with favor unless one were assured of its absolute safety. There are many aeronauts who have made over four hundred ascensions, and this fact alone is a sufficient guaranty of safety under careful management. The modern balloon with its drag rope five hundred feet long, its valve and its rip cord is as safe as almost any other mode of locomotion. It will be found that ninety-nine per cent of the fatal accidents are due to parachute jumps or hot air balloons. Nearly all balloon ascensions have been made at a fair ground or

some exhibition where it is especially desired that a big crowd be present; as a consequence only fair days have been chosen. A balloon ascension with accurate instruments, into a rain-cloud, would give us most valuable data as to the cause of rain, one of the greatest mysteries of modern times. Every explanation of rainfall has signally failed, and there is nothing left but to question nature in her own great laboratory. It has been customary to fill a balloon plump full and then throw off ballast to make the ascension, thereby losing one half to three fourths of all the gas and causing a great deal of labor in handling the ballast. There is a well-known principle that if a balloon leaves the earth at all it will go just as high as if it started full of gas. A thirty-five thousand foot balloon of gold-beater's skin will weigh about one hundred and fifty pounds, and if one fourth full of hydrogen it will take two observers to a height of thirty thousand feet without the loss of gas.

ATMOSPHERIC CONDITIONS IN EUROPE AND AMERICA.

The fact that the atmosphere is remarkably quiescent in Europe, that they have no cold waves, hot waves, cyclones, anticyclones, or any other meteorologic phenomena of any great intensity, should spur on this country to special activity in atmospheric exploration. We can learn more regarding cold waves, for example, in a single ascension than could ever be found out in Europe.

FREE BALLOONS.

It has been thought that records might be brought back by free balloons taking up self-registering apparatus, and at vastly less expense. The first cost of such an enterprise would undoubtedly be less than that of the larger research and the height attained would be greatly in excess, but it should be noted that the results would be comparatively meagre and would mainly serve to make us wish for more. Then the risk of losing such a balloon would be very great and in the end undoubtedly the larger enterprise would be vastly cheaper.

CURRENT NOTES.

New England Meteorological Society. — The thirty-fifth meeting of the New England Meteorological Society was held in the Boylston Chemical Laboratory, Harvard College, Cambridge, Mass., at 3 P. M., Saturday, January 25, 1896; President W. H. Niles in the chair.

Prof. T. W. Richards of Harvard College gave an account of the discovery of argon and helium, explaining the apparatus used by Lord Rayleigh and Prof. Ramsay, and exhibiting tubes containing samples of these gases, made visible by the passage of electric sparks through them. The spectrum of helium was shown.

The difference in the character of nitrogen obtained by decomposing its compounds, and by separating it from atmospheric air, and the manner in which this difference led to the discovery of argon was clearly explained.

The speaker stated that chemists were generally of the opinion that no combination of argon with other substances had yet been effected, in spite of experiments in the presence of many active substances at various temperatures and pressures; the combination reported by Berthelot being doubted.

Mr. H. H. Clayton announced the results of his studies on the movement of cirrus clouds in anticyclones. Investigations previously reported and published had shown that the general eastward movement of the cirrus at Blue Hill is deflected into a curve convex southward in cyclones, and northward in anticyclones; these movements being the resultant of a general eastward drift with a qualified outflow from cyclonic centres, and inflow towards anticyclonic centres. Inasmuch as the curves of cirrus motion aloft agree with the form of the isotherms at sea level, it has been inferred that the distribution of temperature in the lower atmosphere affected the movement of the higher strata.

In order to test this supposition, all examples of anticyclones during the last ten years in which the distribution of surface temperatures was exceptionally equable were sought out and their cirrus movements above Blue Hill were thrown together in a composite diagram. The movements thus shown agree remarkably well in forming an inflowing cyclonic spiral over an area of about five hundred miles radius; and from this the speaker argued that the upper strata must be affected by a distinct centripetal gradient, on which the deflective effect of the earth's rotation seems to have determined a spiral motion. In view of the convincing nature of Hann's studies of anticyclones on the Sonnblick and other Alpine summits, in which low temperature as a cause of the anticyclonic circulation and pressure seems inadmissible, the speaker hesitated to announce definitely a cause for the facts he had discovered. Full publication will shortly be made in the Annals of the Harvard College Observatory.

Prof. W. M. Davis spoke informally on the nature of barometic gradients. We are accustomed to measure the rate of decrease of barometric pressure along a level line, or what corresponds to the same thing, the angle of inclination of an isobaric surface beneath a level surface. While this method of measuring gradients will serve to determine the accelerating force available in a quiet atmosphere, it will not determine the force available to cause motion in a moving atmosphere. In the upper currents of the atmosphere, moving rapidly eastward, we should personify the air, and ask its opinion as to the attitude of a standard surface with respect to which the inclination of isobaric surfaces should be measured. Manifestly, the reply would be, a surface more oblate than that of the ocean. It is with reference to such a surface that local gradients and their differential velocities in the upper strata of the atmosphere should be considered; and it is probably to these differential velocities that the accumulation of air over anticyclones must be ascribed.

The Perth Observatory in West Australia. — The following clipping, from the *South Australian Advertiser*, of Nov. 15, 1895, has been very kindly forwarded to the Editor of this JOURNAL, by Sir Charles Todd, Government Astronomer.

"Last summer when Sir John Forrest was in Adelaide on his way to and from the Premiers' Conference held at Hobart, he informed Sir Charles Todd, the Postmaster General and Government Astronomer, that the Government of West Australia intended to establish an observatory at Perth, and asked Sir Charles if he would advise as to the instruments to get. He also asked him to prepare detailed specifications of same, and plans for the proposed observatory. Sir Charles Todd, with his usual courtesy, prepared full specifications of a transit circle of the same size as the one used at the Adelaide Observatory, with telescope having object glass six inches in diameter, fitted with two graduated circles thirty inches in diameter, divided into five minutes. He also prepared specifications for an equatorial having an object glass of eight inches in diameter. The former instrument was recommended to be made by Mr. James Simms, of the well-known firm of Messrs. Troughton & Simms, and the equatorial by Sir Howard Grubb, of Dublin. Sir Charles wrote fully to Mr. Simms, and also to Sir Howard Grubb, and to the Astronomer Royal, under whose supervision he suggested the instruments should be made. The equatorial will be furnished with a spectroscope and photographic appliances, and also with a sidereal clock to be made by Messrs. Frodsam & Son. The observatory to be erected at Perth is estimated to cost about five thousand pounds for building and instruments, the latter having many improvements on ordinary construction. The improvements have been suggested by experience with the instruments used at the Adelaide Observatory. Having made arrangements for the building of the observatory, the West Australian Government naturally looked about for a gentleman to take the post of astronomer with the result as already announced that Mr. W. Ernest Cooke, the assistant astronomer of South Australia, has been appointed. Sir Charles Todd in

a letter to Sir J. Forrest states: "Mr. Cooke's qualifications are of a very high order. He is a first-class observer and an accomplished mathematician. You are certainly not likely to get a better man from England or one who has had such practical experience." In a second letter Sir Charles wrote as follows: "You could not get a better man. He is an Australian born, and therefore likely to be contented. He has been trained under me in observatory work. He is a splendid mathematician and an able and enthusiastic observer." Mr. Cooke has had a brilliant career. In 1878 he entered the Adelaide University and graduated in 1882, and with his degree of Bachelor of Arts was recommended to receive the South Australian Scholarship of £200 per annum. But the latter he did not take owing to his being offered a position in the Adelaide Observatory. After continuing his studies at the observatory, he took the degree of Master of Arts in 1889. Mr. Cooke, during the time he has been under Sir Charles Todd, has studied astronomy in its theoretical and practical branches, and since his attainment of the chief subordinate post, he has been able to take upon his shoulders much of the work of the Government Astronomer, whose other duties have occupied so much time. Mr. Cooke had sole charge of the observatory while Sir Charles was absent for thirteen months in England, and when he returned he expressed entire satisfaction with the manner in which the work had been carried out."

Clouds Observed from Mont Blanc.—In *Ciel et Terre* for Nov. 16, 1895, M. Janssen, the enthusiastic proprieter of the Mont Blanc Observatory, describes the growth and changes in the clouds observed on Sept. 27, 1895, during his last ascent of the mountain. He says: "Seated in my sledge, and leaving to my guides the entire care of the ascent, I gave myself up completely to the contemplation of the scenes which were successively unrolled before my eyes as I rose higher and higher into these icy solitudes. I noted the phenomena and the impressions. On this occasion, I particularly followed the cycle of transformations which the mist and clouds underwent under the action of the sun during this glorious day, between sunrise and sunset, in this atmospheric stratum of four kilometers in thickness. At the moment of leaving the Grands-Mulets the sun was still behind the great wall of rock formed by the Aiguilles de Charmoz, of Blatière, of Plan, of the Midi, of the Monts-Maudits, etc. The valley of Chamonix was still hidden in the shadows of the morning; it was covered with vapors which seemed to form a bluish lake of sleeping waters. On the east, the ragged edges of the great wall of rocks which dominate the valley were resplendent with light and were surrounded with a halo of sunbeams. In the distance, it looked like an immense sea of stratified vapors bathing the battlements of the Jura, and extending as far as the Vosges, whose bluish outlines were distinguishable on the horizon.

"But soon, as the sun rose, his rays began to penetrate into the valley and to produce curious movements in the sleeping vapors of the night. Light wisps began to rise similar to those which the wind carries off on the plains of Louisiana, at the time when the cotton is ripe. These wisps soon united and formed little clouds, which slowly rose, clinging to the massive

rocks, which seemed to attract them. They finally detached themselves from the latter, in order to rise above them and to float in the free strata of the upper atmosphere. Then it was that from the layers formed by these clouds, there began to rise columns of fantastic shapes, resembling the vegetation which rises from the bottom of the atolls in the coral seas of the great Pacific.

"It was then 10 o'clock, and this singular phenomenon of ascending cloudy columns was at the height of its development. The heat of the sun was intense. Indeed this world of clouds and of vapor could not any longer resist the power of his rays. These ærial palaces fell to pieces. The greater part ascended into the higher regions of the atmosphere, above the summit of Mont Blanc, undoubtedly at an altitude of more than 6,coo metres, and were there dissipated.

"Then the atmosphere assumed a deeper blue tint and the view was extended indefinitely and fathomed the depths of this ærial ocean which is overlooked from these heights, and the extent of which always produces a marvellous impression.

"As I have said, towards 5 o'clock we arrived at the hut of the Rocher-Rouge, after a long and difficult ascent across the crest and the wall of rock. By this time the sun was very low on the horizon and the air was growing rapidly cooler. The dispersed vapors began to condense and to descend towards the valleys, where they fell as dew before the night, which was fine, but very cold. Thus beneath the action of the sun the water and the mists of the valleys had risen in the form of clouds, had reached the higher regions of the atmosphere, had there dissolved and had communicated to this atmosphere the very important properties which this lends to the vapor of water, a principal element in its composition, and then, with the warming strength of this solar action, they had separated themselves and had returned to the valley bottoms, where their function, though quite different, is not less important, thus closing a cycle of changes of which the sun is the originator and regulator. These phenomena are well known, both as to their cause and their appearance, but it is of great interest to be able to observe them, not only from the plains but from elevated points which overlook them, and where their transformations can be followed throughout the whole thickness of the atmospheric stratum which is the scene of their action."

Royal Meteorological Society. — The annual meeting of this Society was held on Wednesday evening, Jan. 15, at the Institution of Civil Engineers, Mr. R. Inwards, F. R. A. S., President, in the chair.

The report of the Council showed that the Society was in a satisfactory condition, thirty-four new Fellows having been elected during the year.

Mr. Inwards devoted his presidential address to the subject of "Meteorological Observatories," which he illustrated with numerous lantern slides. After describing some ancient observatories, including the Nilometers, and the Tower of the Winds at Athens, he gave an account of national observatories, of which the Royal Observatory, Greenwich, was taken as a type. High level observatories were next described, of which that on Mont Blanc

was taken as a type. Special reference was also made to the observatories on the Sonnblick, the high level observatory at Arequipa on the Andes, and that on Ben Nevis. An account was also given of tower observatories, together with some of the results obtained from the Eiffel Tower at Paris. Mr. Inwards in concluding said: "One can figure to oneself a tower piercing the air from any of the elevated tablelands of this country, — Salisbury Plain, the stray at Harrogate, or the downs between Guildford and Dorking, — and from which the most interesting results could not fail to accrue. It is the opinion of M. Vallot, no mean authority, that a high tower is for air-observing purposes equivalent to a mountain station of ten times the altitude; and this is plain when one considers that any mountain must act as an obstacle which thrusts upward the strata of the atmosphere into a form almost like its own, so that some of the effects are very little different from those observed below, while a tower like the Eiffel Tower thrusts itself in the air without obstructing its movements. It is the boast of the Royal Meteorological Society that it is gradually covering the country with a network of private observing stations, and is collecting together, for the enlightenment of all future time, a mass of accurate knowledge on the subject of the changes in our atmosphere, its varying moods, its beating pulses, its calms and its convulsions, so that when the philosopher is born who is destined to unravel all its mysteries, he will have the tools and instruments ready to his hand."

Mr. E. Mawley, F. R. H. S., was elected President for the ensuing year.

Blue Hill Weekly Weather Bulletin. — In this JOURNAL for September, 1894, Vol. XI., p. 197, mention was made of the weekly Weather Bulletin, issued by Mr. H. H. Clayton, of the Blue Hill Observatory. This Bulletin was continued regularly until the end of the year 1895. In the issue for Dec. 28, Mr. Clayton made the following announcement to the subscribers: "With this issue, which ends the second volume, it is thought best to suspend the publication of the weather bulletin. The careful verification of the forecasts made by a number of capable and disinterested men seems sufficient proof that in the average, when a sufficient length of time is taken, the forecasts are better than chance, and are hence based on facts; but at times the succession of occurrences, on which the forecasts are based, reverses after the forecasts are made, so that the succeeding weather comes exactly opposite to that expected. This materially interfered with the utility of the forecasts and might at such times prove dangerous. It is hence thought better to suspend publication until this difficulty can be overcome. The thanks of the editor are extended to the numerous subscribers who have followed the experiment."

The Climates of the Geological Past. — In a book recently published, entitled "The Climates of the Geological Past and their Relation to the Evolution of the Sun," the author, M. Eug. Dubois, after carefully summarizing the geological evidence as to changes of climate in the past, supports the theory that these changes have been due to changes in the amount of heat radiated by the sun. It is assumed that differences in the color

and spectra of the stars indicate differences in their temperatures. From an estimate of the numbers of the stars of each color, white, yellow, and red, the conclusion is drawn that the white stage of color lasts 58.5%; the yellow stage, 33.5%, and the red stage 8% of the total luminous existence of each star. "Since," says M. Dubois, "from the sun's history, we learn that, during the greater part of its existence as a white star, it was much hotter, and on passing relatively rapidly from the white to the yellow stage, it lost much of its heat; we see, on the other hand, that the heat received by the earth underwent the same changes, for after a very long period of warmth, a relatively rapid cooling set in, finally reaching the present condition — then we may assume that the period of the cooling down of the climates coincided with the transition from the white to the yellow stage, the period of rapid cooling of the sun. The present thermal condition at the earth's surface was developed during the Tertiary period, and was fully attained at the beginning of the Pleistocene period — a date, geologically speaking, so recent that the time which has since elapsed may perhaps be estimated as but one fiftieth of the time which elapsed since the beginning of the Palæozoic age. We, therefore, may further conclude that our sun only comparatively recently entered its yellow stage, and we may, without committing a great error, consider that it has now passed three fifths of its life as a luminous and heating star, and that it has still two fifths before it."

Terrestrial Physics at the University of Washington. — Prof. Mark W. Harrington, formerly Chief of the Weather Bureau, announces that it is his purpose to establish in the University of Washington, of which he is now the president, a department of Terrestrial Physics and Geography. He begs, therefore, that authors and publishers will send to him publications relating to these subjects.

Prof. Harrington's present address is as follows: University of Washington, Seattle, Washington.

CORRESPONDENCE.

WEATHER MAPS AND FORECASTS IN PORTUGAL.*

PROF. W. M. DAVIS,

Harvard University, Cambridge, Mass., U. S. A.:

Dear Sir, — I have read in your admirable book, "Elementary Meteorology," on page 328, that Portugal does "not prepare daily maps or issue forecasts." You have been unjust, certainly through inadvertence. The Observatory of the Infante D. Luiz, in Lisbon, began to issue forecasts of the probable weather for the following day on Dec. 1, 1865, and from that same date has displayed the stormy-weather signal at the lighthouses and ports of the kingdom. Since Jan. 1, 1882, a daily map is published, with the isobars, direction of the wind, and the probable weather for the following day. The edition is one hundred and fifty copies. Furthermore, since August, 1888, there has been carried on a free system of warnings for vessels which pass within view of the lighthouses of the coasts of Portugal (see the accompanying notice). This service has been much appreciated by seamen. Yours respectfully,

JOAO CAPELLO.

OBSERVATORIO DO INFANTE D. LUIZ,
LISBOA, Dec. 11, 1896.

METEOROLOGICAL INFORMATION FOR VESSELS PASSING WITHIN VIEW OF THE LIGHTHOUSES. (*Translation.*)

"Since Aug. 1, 1888, there has been in operation a free service of meteorological warnings to vessels which pass within view of the lighthouses on the coast of Portugal. These notices refer to the state of the weather at 7 A. M., in the neighboring regions, north and south; on the north, the Gulf of Gascogne; on the south, the Straits of Gibraltar and the island of Madeira. This service was suggested a long time ago by our illustrious colleague, M. Buys-Ballot, and lately by M. Van Citters, who has made some attempts along this line in Spain and Portugal. Having no simple international signals to represent the state of the weather and the regions in question, we have employed, for the present, the signals of the commercial code, a code which is familiar to all seamen. According to the meteorological bulletins received in the morning from France, Spain, and the island of Madeira, the Observatory of the Infante D. Luiz is in a position to send to the lighthouses very concise telegrams of the state of

* The accompanying communication has been handed to the Editor for publication by Prof. W. M. Davis.

the weather north and south of our coast. These are the telegrams or notices which are sent gratis to the ships which want to know the state of the weather over one of these three districts. The lighthouses chosen are: Sagres (Cape St. Vincent), Cape Espichel, Oitavos (mouth of the Tagus), Cape Carvœiro, and Luz (Oporto).

"For the two southern districts (Straits of Gibraltar and Madeira) the notices will usually be sent from the observatory at noon; for the Gulf of Gascogne they will be sent a little later, generally at 2 P. M. Before these hours the notices refer to the day previous, and likewise during the afternoon, if the lighthouses have not yet received the telegrams from the observatory. In all cases the date must always precede the warnings.

"Ordinarily the state of the weather is announced by the direction and force of the wind; the first, by the eight directions N., N. E., E., S., etc., and the force by the words calm, light, moderate, fairly strong, violent. Notice has been sent to navigators regarding this new free service of the lighthouses, all the details being given."

[This circular is signed by J. Capello, and dated July 20, 1888. — ED.]

THE MEASUREMENT OF TEMPERATURE AT DISTANT POINTS.

Editor of the American Meteorological Journal:

In connection with Dr. Bauer's note in the January number of this JOURNAL, page 287, calling attention to a form of electrical thermometer described by Prof. Eschenhagen, it seems desirable to mention that identically this kind of a thermometer, that is, a mercurial thermometer having a fine platinum wire stretched within the bulb and tube, was used for several months at the Signal Office in Washington nearly ten years before being described by Prof. Eschenhagen. A description of the thermometer by Prof. T. C. Mendenhall, together with a much more exact equation expressing the relation of temperature and resistance than given by Dr. Bauer, will be found in Silliman's "American Journal" for August, 1885; also in the "Philosophical Magazine" for October, 1895. This form of electrical resistance thermometer was employed at that time among others for observing earth temperatures, and both telephones and galvanometers were used in measuring the resistance.

The equation given by Prof. Mendenhall is $R_t = R_o - [s(1 - kl) - g]t - (ks - gh)\,t^2$, in which R_t and R_o are the total resistance of the thermometer at temperatures t degrees and o degrees respectively.

l = length of wire exposed at 0°.

s = resistance of wire per unit length (*i. e.*, length of 1°).

g = resistance of mercury per unit length (*i. e.*, length of 1°).

k = temperature co-efficient of platinum.

h = temperature co-efficient of mercury.

In the equations cited by Dr. Bauer account is taken of the variation in the resistance due simply to the change in the lengths of wire and mercury while the effect of temperature in changing the conductivity is quite ignored.

These quantities are of such magnitude as to noticeably affect the indications of the thermometer.

The utility of a thermometer of this type is greatly limited from several causes, and it is practically useless at remote distances, such as on mountain summits and in captive balloons, especially for ascertaining air temperatures. The bore of the stem of a good thermometer for observing air temperatures is exceedingly fine, and this must be enormously enlarged in the electrical thermometer to permit of the introduction of even a fine platinum wire. If any degree of sensitiveness is to be secured the thermometer bulb must also be proportionally large and, as a result, the thermometer is so sluggish that its use for observing air temperatures is quite out of the question. The electrical resistance of the thermometer must always remain comparatively small, so that when placed at any remote point the resistance of the connecting wires, and especially the variations of the latter resistance with temperature, become of serious consequence and may greatly mask and conceal the variations in the resistance of the thermometer itself.

C. F. MARVIN,
Professor in Charge, Instrument Room.

WASHINGTON, D. C., Jan. 10, 1896.

BIBLIOGRAPHICAL NOTES.

A TRANSLATION OF THE ASTRONOMY AND METEOROLOGY OF ARATUS.

C. LEESON PRINCE, M. R. C. S., F. R. A. S., F. R. MET. SOC. *A Literal Translation of the Astronomy and Meteorology of Aratus, with some Bibliographical Remarks.* 8vo, Lewes, 1895. Pp. viii, 82.

It gives us great pleasure to publicly express our thanks to Mr. C. Leeson Prince, for the admirable book he has given to meteorologists in his "Translation of the Astronomy and Meteorology of Aratus." He has certainly laid all of us under an obligation to himself, which is all the greater because this translation and the care and thought which he has given to the publication of this work have been simply and solely a labor of love. England is certainly fortunate in having among its meteorologists such men as Mr. G. J. Symons and Mr. Prince, who for the love of the science, give their fellow-workers such translations, admirably edited and most attractively gotten up, as Theophrastus on Winds and Weather Signs, and Aratus on Astronomy and Meteorology.

Mr. Prince tells us in his preface that his residence in a rural district, and the necessity, occasioned by his profession as a physician, of being much out of doors at all hours of the day and night, have combined to give him "ample opportunities for observing and recording various meteorological phenomena which too generally escape the notice of many, whose occupation or inclination does not afford them the same opportunities." Being thus much interested in weather changes and weather signs, our author, more than twenty years ago, published a literal English prose translation of the "*Diosemeia*," or weather prognostics, of Aratus, together with some local weather prognostics, derived from his own observations upon the behavior of animal and vegetable life. The present volume contains, besides the translation of the "*Diosemeia*," a translation of Aratus' first poem, "The Phenomena," which consists of a discourse on the ancient form and designation of the several celestial constellations, and a list of local and other weather prognostics, partly gathered from classical writers and partly the results of the author's own studies and observations.

Aratus, as we learn from the preface, was born at Soli, a city of Cilicia, so named after Solon, but subsequently called Pompeiopolis, after Pompey the Great. The date of his birth is involved in some obscurity, but it is certain that he flourished in the CXXV Olympiad (B. C. 278), and lived at that time in the palace of Antigonus Gonatas, King of Macedonia. Aratus fol-

lowed the profession of medicine, but gave much time to the study of astronomy, poetry, rhetoric, and philosophy. Nearly all his writings have been lost except the "*Phenomena*" and the "*Diosemeia.*" The "*Phenomena*" was extremely popular for several centuries. It was translated into Latin by Germanicus Cæsar, and later, both it and the "*Diosemeia*" were translated into Latin by R. Festus Avienus. The ideas as to the astronomical constellations set forth in the "*Phenomena*" were not those of Aratus, but of other writers on astronomical subjects who preceded him, especially of Eudoxus Cnydus. The "*Diosemeia*" first appeared in English in 1848, in metrical form, from the pen of Dr. Lamb, and in 1871, in prose form, as the work of Mr. Prince. Since then two other metrical versions have been published, one by Mr. E. Poste, M. A., in 1880, and the other by Mr. Brown, F. S. A., in 1885.

Mr. Prince prefaces his translations with some bibliographical remarks, carefully prepared and of much interest. The "*Phenomena*," a piece of writing which is not of any direct meteorological interest, is of distinct value to persons interested in astronomy as giving the ideas current in the time of Aratus regarding the heavenly bodies. The "*Diosemeia*" are well worth careful reading. In this poem Aratus gives various weather prognostics derived from phenomena connected with the moon, sunrise and sunset; the habits of sea-birds; the appearance of the clouds; the motion of the wind upon the sea-shore; the habits of birds, animals, etc.

Many of these weather proverbs are still current in our own day, and sound quite familiar when read. Among these the following may be noted: "If the sun has redness, as often happens, and he becomes red on every side by gathered clouds, or he grows less brilliant, these are signs of approaching rain; if altogether red, wind is indicated; but if both colors are present at the same time rain and wind will follow." "Observe in summer whence comes the lightning and thunder, that you may know from what quarter the wind is likely to come." "Often at the approach of rain the clouds at first appear much like pieces of wool, or a double iris bestrides the great sky, or some star has its appearance rendered very dim. . . . Swallows . . . fly quickly around a lake and strike with their breasts the vibrating water." "If a dark cloud extends along the valley near a high hill, whilst its summit remains clear, you will have fine weather." "The oak tree, covered with their acorns, and the black mastick tree are not without a sign. The husbandman often examines them, hoping that the summer may not pass by without their fruit being secured, and should they be well covered with acorns they announce a rigorous winter."

The last section of Mr. Prince's book is entitled "Some Remarks upon Local and other Weather Prognostics," and includes local prognostics which the author thinks are deserving of observation, together with some collected from ancient classical authors. Regarding this matter the author says: "Besides the indications to be afforded by scientific instruments the careful observation of many natural phenomena connected with the habits of animals, birds, insects, etc., give such useful warning of important changes in the weather as will amply repay those who give due attention to the subject, while those who do *not* are often sceptical as to the value of such

prognostics. However, for many years I have paid such close attention to most of the recorded prognostics that I am justified in endorsing the expressed opinions of the ancients respecting them, and more particularly those which have stood the test of two thousand years and upwards." We are inclined to think that many, if not most, persons will disagree with Mr. Prince in his estimation of the value of these local prognostics connected with the behavior of animals and plants; yet his opinion, based on many years' observations, is certainly worthy of careful consideration. If we mistake not, Mr. Lowe, F. R. S., some few years ago made an investigation of a good many of the most popular weather proverbs and prognostics and found that they are in most cases useless as indicating coming weather changes.

The prognostics are classified according to the following scheme: —

1. Prognostics of Seasons.
2. From Scientific Instruments.
3. From Sunrise and Sunset.
4. From the Rainbow.
5. From Solar and Lunar Halos.
6. From Habits of Animals.
7. From Birds.
8. From Insects.
9. From Plants.
10. Miscellaneous Prognostics.

Most of the prognostics included in this list are familiar, but we do not remember ever to have seen the following: —

"When a carriage wheel rotates rapidly along a dusty road it raises three ridges of dust; if the central ridge lies flatter than the others, expect rain within thirty-six hours. When you gently drop water from a feather upon water, and you find that the drops, instead of at once mingling with the water, float away upon its surface, expect rain."

We welcome Mr. Prince's little volume as a fitting companion to Mr. Symons's recent publication of Theophrastus "On Winds and Weather Signs." These two books should certainly be placed together on the shelves of every meteorological library. The historical aspect of meteorology is one of great interest, and such books as these represent landmarks in the historical aspect of the science. The frontispiece of Mr. Prince's Aratus is a photographic reproduction of an engraving representing the revolution of the planets around their supposed primary in the order assigned to them by the ancients in the time of Aratus. The engraving first appeared in the edition by Hugo Grotius, published at Leyden in 1600. The Aratus is most fittingly dedicated to Mr. Symons, "as a small tribute to his zeal for the recognition and reproduction of ancient meteorology." We regret very much that the edition of the Aratus is so small, and that it is not intended for general sale.

PROCEEDINGS OF THE ANTWERP CONGRESS OF THE SCIENCE OF THE ATMOSPHERE.

A. LANCASTER. I. *Sur les Cartes Synoptiques du Temps.* II. *Sur la Nature du Vent.* III. *Sur la Force du Vent en Belgique.* Communications faites à la Congrés de la Science de l'Atmosphère, Anvers 16–18 Août, 1894. 8vo. Anvers, 1895. pp. 59. Pl. 3.

The present volume contains three of the papers read at the Antwerp Meteorological Congress in August, 1894, by M. Lancaster, Vice-President of the Congress and President of the First Section. The subjects of these papers are as follows: I. The Daily Weather Maps. II. On the Nature of the Wind. III. On the Force of the Wind in Belgium.

In the first paper, after noting the very great importance of the daily weather map, the author refers to the value of the international daily weather maps formerly prepared by our Signal Service, the Paris Observatory, the Danish Meteorological Institute, and the Deutsche Seewarte, whose continued publication had to be given up, owing to the enormous expense incurred. In order to ensure the continued publication of such international weather maps, as well as charts of cyclonic and anticyclonic tracks, the monthly and annual distribution of atmospheric currents, etc., M. Lancaster strongly advocates the establishment of an international meteorological institute, in Western or Central Europe, this institute to have charge of all such matters of international interest.

In the second paper, on the nature of the wind, extended quotations are given from the writings of M. Houzeau, who made careful investigation of the nature, or, as he most aptly termed it, the "texture" of the wind. His views were similar to those more recently expressed by Langley, in his "Internal Work of the Wind." The author mentions some cases which have come under his own observation of the erratic and irregular action of the wind.

The third paper, on the force of the wind in Belgium, gives some valuable results based on observations made at Brussels, from 1850 to 1889, on the force and velocity of the wind. From 1850 to 1878, the observations relate to the pressure of the wind, expressed in kilograms per square meter; from 1879 they relate to the velocity of the wind in meters per second. Many interesting conclusions are drawn from the tables, among which the following are noted: the greatest pressure of the wind is observed from October to March, during the winter season, for it is under the influence of deep depressions that the most violent winds occur, as a rule, and these depressions are most frequent in winter. West and west-southwest winds are those which exert the greatest pressure. The hours from 1 to 3 P. M. are those during which the maxima of wind pressure are most frequent, but the absolute maxima of pressure generally occur between 7 P. M. and 1 A. M. In other words, violent gusts of wind are most frequent between 1 and 3 P. M.; but the mean intensity of the gusts is greatest between 5 and 11 P. M. The windiest months are November to March; the calmest, June to September.

We had our doubts as to the success of the Antwerp Meteorological Congress, when we first received notice of its meeting; but now that we have read some of the papers it called forth we think its promoters were fully justified in their undertaking.

BULLETIN OF THE ASTRONOMICAL OBSERVATORY OF QUITO.

AUGUSTO N. MARTINEZ. *Boletin del Observatorio Astronomico de Quito.* Año I. Num. 1. Octubre de 1895. 8vo. Quito, 1895. Pp. 12.

We received some weeks ago the first number of the new Bulletin of the Quito Astronomical Observatory, issued under the direction of Augusto N. Martinez. It is an octavo publication of twelve pages, and contains tables of tri-daily barometer, psychrometer, and thermometer readings; state of sky and direction of wind; evaporation: rainfall. There is also a comparative table of the chief meteorological data during the month of October in 1878, 1879, 1880, and 1881.

TITLES OF RECENT PUBLICATIONS.

FURNISHED BY MR. OLIVER L. FASSIG, LIBRARIAN, U. S. WEATHER BUREAU, WASHINGTON, D. C.

(An asterisk [*] indicates that the publications thus designated have been received by the Editor of this JOURNAL.)

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* BLUE HILL METEOROLOGICAL OBSERVATORY. *Observations made in the year 1894. Under the direction of A. Lawrence Rotch. With an appendix containing anemometer comparisons.* (Extr.) Annals Harvard College Observatory, Cambridge, 1895, vol. xl. 93 pp. 3 pl.

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* HOLLAND K. NEDERLANDSCH METEOROLOGISCH INSTITUNT. *De Guinea en Equatoriaal Stroomen.* 14 x 23 inches. Utrecht, 1895. 4 pp. 24 charts.

* LONDON. ROYAL METEOROLOGICAL SOCIETY. *The meteorological record. Monthly results of observations made at the stations of the society, with remarks on the weather for the quarter ending March* 31, 1895. By William Marriott. Vol. xv. No. 57. 8vo. London, 1895. The same for the quarter ending June 30, 1895.

* NEW ENGLAND WEATHER SERVICE. *Observations in the year* 1894. J. Warren Smith, Weather Bureau, Director. (Extr.) Annals Harvard College Observatory, Cambridge. Vol. xli. (1895), 31 pp. 1 ch.

* NEW YORK METEOROLOGICAL BUREAU. *Fifth annual report of the Meteorological Bureau and Weather Service of the State of New York,* 1893. 8vo. Albany, 1894. 457 pp. 44 charts. (Pp. 345–448. 19 pl. The Climate of the State of New York. By E. T. Turner.)

RIJCKEVORSEL, DR. VAN. *A magnetic survey of the Netherlands for the Epoch Jan.* 1, 1891. (N. Verh. Bataafsch Genootschap.) 4to. Rotterdam, 1895. 103 pp. 17 tables. 10 pl. (Buitengewone Aflevering).

ST. PETERSBURG. K. RUSSISCHE GEOGR. GESELLSCHAFT. *Beobachtungen der Rus sischen Polarstation an der Lenamündung. Station Ssagastye.* I. Theil-*Astronomische und magnetische Beobachtungen,* 1882–1884. Die Lena-Expedition, 1881–1884. Beschreibung von Dr. A. Bunge. 4to. [St. Petersburg], 1895. iv (88), 166, 96, vi pp. 2 ch. 5 pl. Hrsg. unter Redaction von Dr. A. v. Tillo.

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